PROC. ENTOMOL. SOC. WASH.
99(3), 1997, pp. 440–460

A NEW SPECIES OF MEALYBUG IN THE GENUS *DYSMICOCCUS* (HEMIPTERA: COCCOIDEA: PSEUDOCOCCIDAE) OF IMPORTANCE IN HIGHBUSH BLUEBERRIES (*VACCINIUM CORYMBOSUM*, ERICACEAE) IN THE EASTERN UNITED STATES

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Abstract.—A new species of mealybug, ***Dysmicoccus vaccinii* Miller and Polavarapu**, is described that is believed to be a pest of highbush blueberries, *Vaccinium corymbosum* L. It has an unusual life history since most instars can be found in the field throughout the year, including January and February. The four female instars and five male instars are described and illustrated, including apterous and macropterous adult males. The blueberry mealybug is suggested as a common name. **New synonymy** is included as follows: *Dysmicoccus bispinosus* Beardsley is considered to be a junior synonym of *D. texensis* (Tinsley).

Key Words: Mealybugs, Coccoidea, Pseudococcidae, pest, blueberry, *Vaccinium,* roots, ants, *Acanthomyops, Lasius,* mutualism

Infestations of an undescribed species of mealybug belonging to the genus *Dysmicoccus* were discovered several years ago on the roots of highbush blueberries (*Vaccinium corymbosum* L.) in southern New Jersey. This genus encompasses more than 100 species (Ben-Dov 1994) including several major pests such as the gray sugarcane mealybug, *D. boninsis* (Kuwana) and the pineapple mealybug, *D. brevipes* (Cockerell).

The infestations n New Jersey are becoming increasingly prevalent especially in the light sandy-loam soils of Atlantic County. Although the impact of the mealybug on blueberry production and fruit quality has not been quantified, severe infestations appear to reduce vigor and lead to stunting of young plants. Circumstantial evidence has implicated this species as a vector of the Red ringspot virus (belonging to the Caulimovirus group of viruses), the causal agent of the Red ringspot disease in blueberries (Ramsdell et al. 1987). Red ringspot is one of the most important viral diseases of blueberries in New Jersey and also occurs in Arkansas, Connecticut, Massachusetts, Michigan, New York, North Carolina and Oregon (Ramsdell et al. 1987).

The purpose of this research is 1) to name this species and describe its morphological characters so that it can be differentiated from similar species, 2) to provide preliminary information on the biology of the species, and 3) to incorporate it in a key to adult females of *Dysmicoccus* so that the new species can be accurately identified.

In order to describe the new species and compare it with the most similar species, it is necessary to make the following nomenclatural changes effecting the status of *Dysmicoccus bispinosus* Beardsley and *D. tex-*

ensis (Tinsley). DRM has examined type specimens of these species and concludes that they belong to only one species (**new synonymy**). Since *D. texensis* was described by Tinsley in 1900 and *D. bispinosus* was described by Beardsley in 1965, by the law of priority the correct name of the species is *Dysmicoccus texensis*. Since type material of *Pseudococcus texensis* is a syntype series, we have selected as **lectotype** the left adult female specimen mounted on a slide with 1 other adult female with the left label "*Dactylopius/ texensis* (Tinsley)/Type/on *Acacia/ farnesiana/* San Diego, Texas/ E. A. Schwarz coll./ Dec. 1895 1899"; the right label contains a map giving the location of the lectotype and states "*Pseudococcus/ texensis* /LECTOTYPE/ PARALECTOTYPE/ ." In addition to the lectotype there are 28 adult female paralectotypes on 6 slides; all specimens are in the USNM.

Methods

To determine the percent of the mealybug population in different stages at various times of the year, 1–2 infested blueberry plants were collected at approximately 1–2 month intervals from an infested blueberry field in Hammonton, New Jersey. Plants were gently uprooted with minimal disturbance to the root system. Each plant along with the surrounding soil were placed in a 30-gal plastic bag for further examination. In the laboratory, the root-system and the accompanying soil from each plant sample were carefully examined for different mealybug stages. This sampling procedure may be biased against the minute, early instar nymphal stages, but should nevertheless provide a qualitative measure of the occurrence of various stages of the insect. Mealybug samples were preserved in 70% alcohol and shipped to the Systematic Entomology Laboratory (SEL) for identification of different stages of the insect.

Terminology in the descriptions follows that of Williams and Granara de Willink (1992) and Gimpel and Miller (1996) for adult females and immatures and that of Afifi (1968) for adult males. Measurements and numbers are from 10 specimens when available, and are given as an average followed by the range in parentheses. Enlargments on illustrations are not proportional. Depositories of specimens are: The Natural History Museum, London (BMNH); California Department of Food and Agriculture, Sacramento (CDA); Florida State Collection of Arthropods, Gainesville (FSCA); Muséum National d'Histoire Naturelle, Paris (MNHN); University of California, Davis (UCD); National Museum of Natural History, Beltsville, MD (USNM).

Results

Dysmicoccus vaccinii Miller and Polavarapu, new species

Suggested Common Name: Blueberry mealybug

Type data.—The adult female holotype is mounted alone on a slide with the left label "NEW JERSEY/ Hammonton, Variety/ Farms, Atlantic Co.,/ 17-XI-1994/ ex. Blueberry/ S. Polavarapu" right label "*Dysmicoccus/ vaccinii/* Miller and Polavarapu/ HOLOTYPE" . This slide is deposited in the USNM. In addition there are 1,354 paratypes on 185 slides that are deposited in BMNH, CDA, FSCA, MNHN, UCD, USNM.

Etymology.—The species epithet is the genitive form of the blueberry host genus *Vaccinium*.

Adult Female
(Fig. 1)

Slide-mounted characters.—Holotype oval, length 1.9 mm, width 1.1 mm. Paratypes 1.7(1.4–1.9) mm long, 1.1(0.8–1.2) mm wide.

Dorsum with 17 pairs of cerarii, cerarian formula as follows: Left side 1–6(2), 7(3), 8–11(2), 12(3), 13–14(2), 15(3), 16(2), 17(4); paratypes with cerarius 1 with 2 conical setae, cerarius 2 with 2(2–3) conical setae, cerarius 3 with 2(1–2) conical setae, cerarius 4 with 2(2–3) conical setae, cerarius 5 with 2(1–3) conical setae, cerarius 6 with 2(1–2) conical setae, cerarius 7 with 2(2–3) conical setae, cerarius 8 with 2(1–3) conical setae, cerarius 9 with 2(1–3) conical setae, cerarius 10 with 3(2–3) conical setae, cerarius 11 with 2(1–3) conical setae, cerarius 12 with 3(3–4) conical setae, cerarius 13 with 2(1–3) conical setae, cerarius 14 with 2(2–3) conical setae, cerarius 15 with 3(2–5) conical setae, cerarius 16 with 5(3–7) conical setae, cerarius 17 with 4(3–5) conical setae. Cerarius 12 with 3 auxiliary setae (paratypes with 3(1–5) setae), 24 trilocular pores (paratypes with 23(17–27) pores), and 5 discoidal pores (paratypes with 3(1–5) pores). Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores about equal to diameter of trilocular pore. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 27 μ long (paratypes 30(22–37) μ); 6 submedial setae on segment VIII (paratypes 6(5–6) setae), longest seta 30 μ long (paratypes 34(25–42) μ).

Anal ring seta 116 μ long (paratypes 117(101–143) μ); 1.4 times as long as greatest diameter of ring (paratypes 1.4(1.3–1.6) times).

Venter with multilocular pores in posterior and anterior bands on segments VI–VIII, in posterior band on segment V (paratypes sometimes with 1 or 2 pores near anterior margin of segment V and near posterior margin of segment IV), without pores on thorax (1 of 10 paratypes with 1 pore on prothorax near anterior leg). Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1 discoidal pore near eye on 1 side of body, absent near other eye (paratypes with 1(0–2) pores near each eye. Oral-collar tubular ducts of 1 size, present near marginal and submarginal areas of abdomen and near setal bases in medial and submedial areas of abdomen and thorax, 1 oral collar mesad of cerarius 12 (paratypes 2(0–5) ducts), without oral collars in marginal or submarginal areas of thorax or head. Setae as follows: 6 cisanal, (paratypes 4(3–6), longest 42 μ long (paratypes 44(37–49) μ); longest anal-lobe seta 148 μ long (paratypes 157(124–168) μ); longest seta on trochanter 111 μ long (paratypes 109(99–124) μ).

Circulus 96 μ wide (paratypes 90(74–104) μ), divided by intersegmental fold. Labium 161 μ long (paratypes 170(161–180) μ). Antennae 8-segmented, (paratypes rarely 7-segmented) 353 μ long (paratypes 341(316–366) μ). Legs with 33 translucent pores on hind femur (paratypes 29(15–52) pores); 21 pores on hind tibia (paratypes 24(8–37) pores). Femur 212 μ long (paratypes 210(185–235) μ); tibia 198 μ long (paratypes 190(170–217) μ); tarsus 91 μ long (paratypes 99(91–101) μ). Tibia/tarsus 2.2 (paratypes 2.0(1.8–2.3)); femur/tibia 1.1 (paratypes 1.1(1.1–1.2)). Hind tibia with 19 setae (paratypes 19(16–23) setae). Length of hind femur divided by greatest width of femur 3.1(2.9–3.4). Claw digitules on hind 2 pairs of legs clubbed, each claw with 1 digitule with club slightly larger than club on other digitule; claw digitules of front pair of legs clubbed, about equal in size. Tarsal digitules on hind 2 pairs of legs apically clubbed, each tarsus with 1 digitule with club noticeably larger than club on other digitule; tarsal digitules on front pair of legs of 2 different sizes and shapes, 1 digitule on each tarsus clubbed and nearly reaching tip of claw, other digitule short and apically acute.

Notes.—The above description is based on 733 specimens from 4 localities. Adult females can be distinguished from all other instars by having multilocular pores, translucent pores on the hind femur and tibia, and a vulva.

Third-instar Female
(Fig. 2)

Slide-mounted characters.—Body oval, 1.2(1.0–1.4) mm long, 0.8(0.6–0.9) mm wide.

Dorsum with 17 pairs of cerarii, cerarii 1 and 2 with 2 conical setae, cerarii 3 and 4 with 2(1–2) conical setae, cerarius 5 with 2

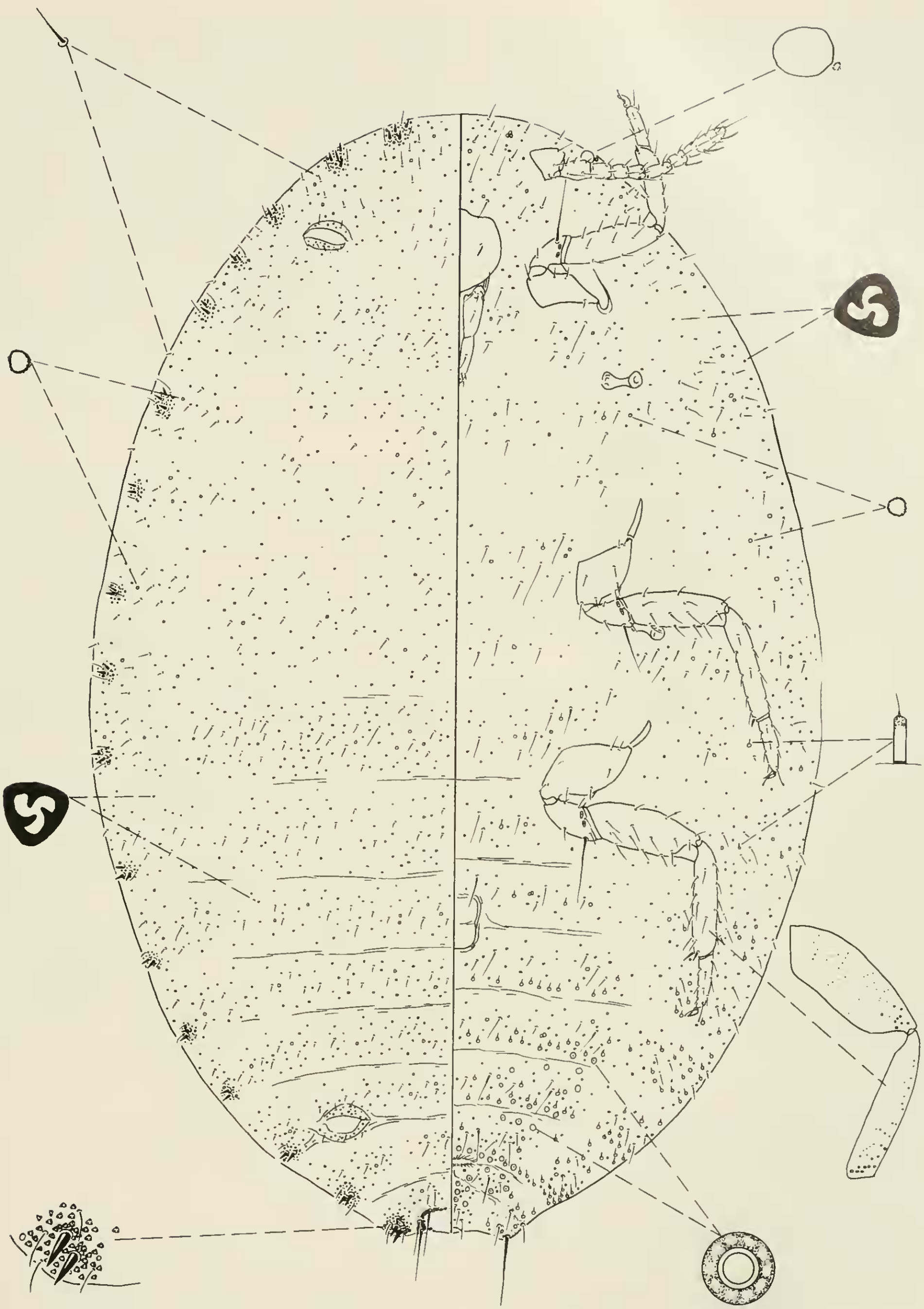

Fig. 1. Adult female *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, XI-17-1994, on *Vaccinium corymbosum*, S. Polavarapu.

conical setae, cerarius 6 with 2(0–2) conical setae, cerarius 7 with 2 conical setae, cerarius 8 with 2(0–2) conical setae, cerarius 9 with 2(1–2) conical setae, cerarius 10 with 2(0–3) conical setae, cerarius 11 with 2(1–2) conical setae, cerarius 12 with 3(2–3) conical setae, cerarius 13 with 2(1–2) conical setae, cerarius 14 with 2(1–3) conical setae, cerarius 15 with 3(2–3) conical setae, cerarius 16 with 4(3–4) conical setae, cerarius 17 with 3(3–4) conical setae. Cerarius 12 with 1(0–3) auxiliary setae, 10(7–14) trilocular pores, and 1(1–2) discoidal pores. Multilocular pores absent; trilocular pores evenly scattered over surface; discoidal pores about equal to diameter of trilocular pore. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 24(19–28) μ long; 3(3–4) submedial setae on segment VIII, longest seta 25(20–28) μ long.

Anal ring seta 93(86–101) μ long; 1.5(1.4–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–2) pores near each eye. Normally with 1 oral-collar tubular duct in cluster of setae posterior of each spiracle; oral collars absent elsewhere. Setae as follows: 4 cisanal setae, longest 31(25–37) μ long; longest anal-lobe seta 125(111–138) μ long; longest seta on trochanter 71(54–82) μ long.

Circulus 62(49–74) μ wide, divided by intersegmental fold. Labium 131(122–136) μ long. Antennae 6- or 7-segmented, 244(230–259) μ long. Legs without translucent pores. Femur 136(131–143) μ long; tibia 105(96–109) μ long; tarsus 89(84–95) μ long. Tibia/tarsus 1.2(1.1–1.2); femur/tibia 1.3(1.2–1.4). Hind tibia with 10(8–11) setae. Length of hind femur divided by greatest width of femur 2.4(2.3–2.7). Claw and tarsal digitules same as in adult female.

Notes.—This description is based on 313 specimens from 3 localities. The third-instar female can be distiguished from all other instars by having each cerarius with conical setae, antennae usually 7-segmented, rarely 6, hind tibia length divided by hind tarsus length 1.1 to 1.2, usually 1.2, and cerarius 12 with 7–14 associated trilocular pores. It is most similar to the second-instar female which differs by having cerarii anterior of cerarius 7 without conical setae (cerarian setae are filamentous), antennae usually 6-segmented, hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores.

Second-instar Female
(Fig. 3)

Slide-mounted characters.—Oval, 0.9(0.8–1.0) mm long, 0.5(0.5–0.6) mm wide.

Dorsum with 17 pairs of cerarii, posterior cerarii to cerarius 7 or 8 usually with at least 1 conical seta and 1 filamentous seta, cerarii 1–6 with 2 setae, cerarii 7–9 with 2(1–2) setae, cerarius 10 with 2(1–3) setae, cerarius 11 with 2(1–2) setae, cerarius 12 with 3(2–3) setae, cerarius 13 with 2(1–2) setae, cerarius 14 with 2(1–2) setae, cerarius 15 with 3(2–3) setae, cerarius 16 with 2(1–2) setae, cerarius 17 with 3(3–4) setae. Cerarius 12 with 3(2–5) trilocular pores, and 1(0–1) discoidal pores. Multilocular pores absent; trilocular pores scattered over surface; discoidal pores about equal to diameter of trilocular pores. Oral-collar-tubular ducts absent. Longest submedial seta on segment VII 17(15–22) μ long; 1(0–2) submedial setae on segment VIII, longest seta 14(12–16) μ long.

Anal ring seta 66(57–79) μ long; 1.5(1.3–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–2) pores near each eye. Without oral-collar tubular ducts. Setae as follows: 4 cisanal setae, longest 23(17–27) μ long; longest anal-lobe seta 93(84–99) μ long; longest seta on trochanter 71(54–82) μ long.

Circulus 44(35–52) μ wide, divided by

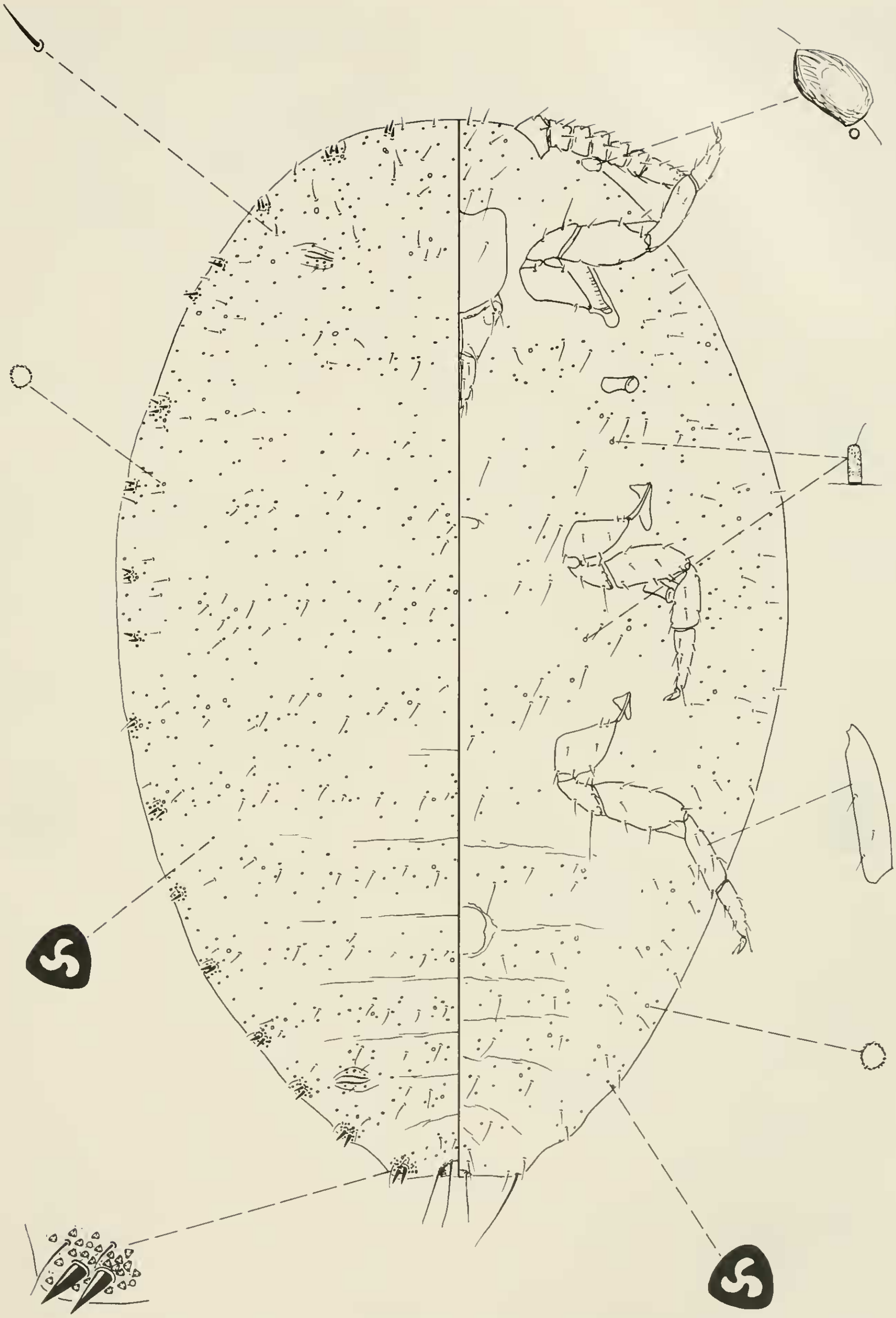

Fig. 2. Third-instar female *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller.

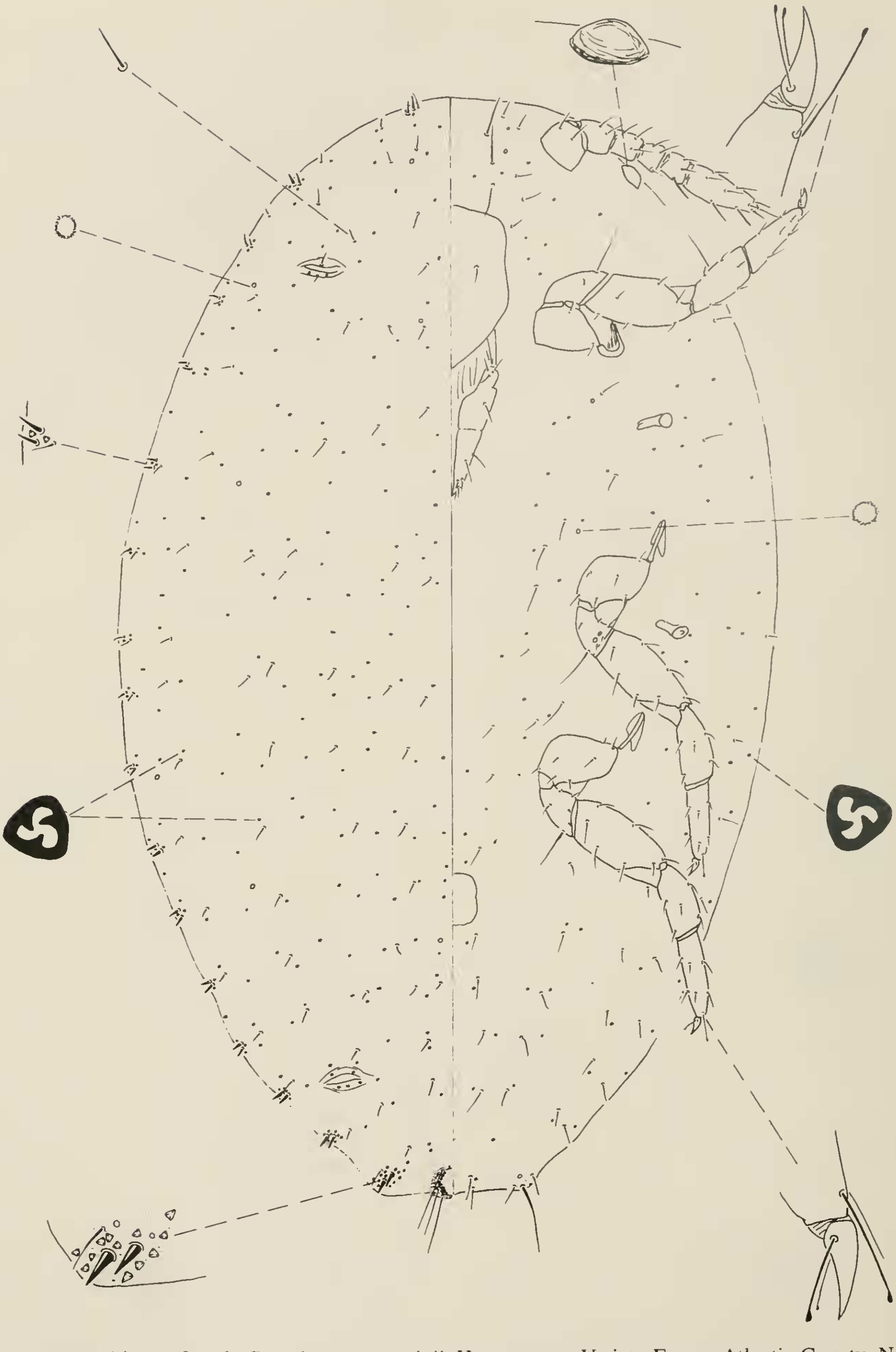

Fig. 3. Second-instar female *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller.

intersegmental fold. Labium 99(94–104) μ long. Antennae 6-segmented, 244(230–259) μ long. Legs without translucent pores. Femur 91(86–99) μ long; tibia 67(62–73) μ long; tarsus 74(69–79) μ long. Tibia/tarsus 0.9; femur/tibia 1.4(1.3–1.4). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.2(2.0–2.4). Claw digitules same as on adult female. Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same as other legs except apically acute digitule is very short.

Notes.—This description is based on 78 specimens from 3 localities. The second-instar female can be distiguished from all other instars by having antennae usually 6-segmented, hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores. It is most similar to the second-instar male which differs by having oral-collar tubular ducts; these are absent on the second-instar female.

First Instar
(Fig. 4)

Slide-mounted characters.—Oval, 0.6(0.5–0.7) mm long, 0.3(0.3–0.4) mm wide.

Dorsum with 16 pairs of definite cerarii, anterior cerarius indefinite, posterior cerarii to cerarius 2, 3, or 4 with at least 1 conical seta and 1 filamentous seta, cerarii 1–9 with 2 setae, cerarius 10–16 with 2(1–2) setae, cerarius 17 indefinite, represented by 1 or more unassociated setae. Cerarius 12 with 1 trilocular pore. Multilocular and discoidal pores absent; trilocular pores arranged in 4 longitudinal lines on each side of body. Oral-collar tubular ducts absent. Longest submedial seta on segment VII 10(8–11) μ long; without submedial setae on segment VIII.

Anal ring seta 52(47–54) μ long; 1.7(1.6–1.9) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores arranged in 1 mediolateral longitudinal line on each side of abdomen, more abundant on thorax and head. Discoidal pores associated with base of sublateral line of setae, also with 1 associated with each spiracle, with 1(0–1) pore near each eye. Without oral-collar tubular ducts. Setae as follows: 4 cisanal setae, longest 18(16–22) μ long; longest anal-lobe seta 50(42–61) μ long; longest seta on trochanter 39(32–44) μ long.

Inner circle of circulus 30(27–35) μ wide, divided by intersegmental fold. Labium 76(64–83) μ long. Antennae 6-segmented, 142(128–158) μ long. Legs without translucent pores. Femur 63(59–68) μ long; tibia 46(42–49) μ long; tarsus 60(56–65) μ long. Tibia/tarsus 0.8(0.7–0.8); femur/tibia 1.4(1.3–1.5). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.1(1.9–2.3). Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same as other legs except apically acute digitule is very short.

Notes.—This description is based on 70 specimens from 3 localities. The first instar can be distiguished from all other instars by having 6-segmented antennae, hind tibia length divided by hind tarsus length 0.7–0.8, usually 0.8, and cerarius 12 with 1 associated trilocular pore. It is most similar to the second-instar female which differs by having hind tibia length divided by hind tarsus length 0.9, and cerarius 12 with 2–5 associated trilocular pores.

Second-instar Male
(Fig. 5)

Slide-mounted characters.—Body oval, 0.9(0.8–1.0) mm long, 0.6(0.5–0.6) mm wide.

Dorsum with 17 pairs of cerarii, posterior cerarii to cerarius 4 or 5 usually with at least 1 conical seta and 1 filamentous seta, cerarii 1–7 with 2 setae, cerarii 8 and 9 with 2(1–2) setae, cerarius 10 with 2(1–2) setae, cerarius 11 with 2 setae, cerarius 12 with 2(1–3) setae, cerarius 13 with 2(1–2) setae,

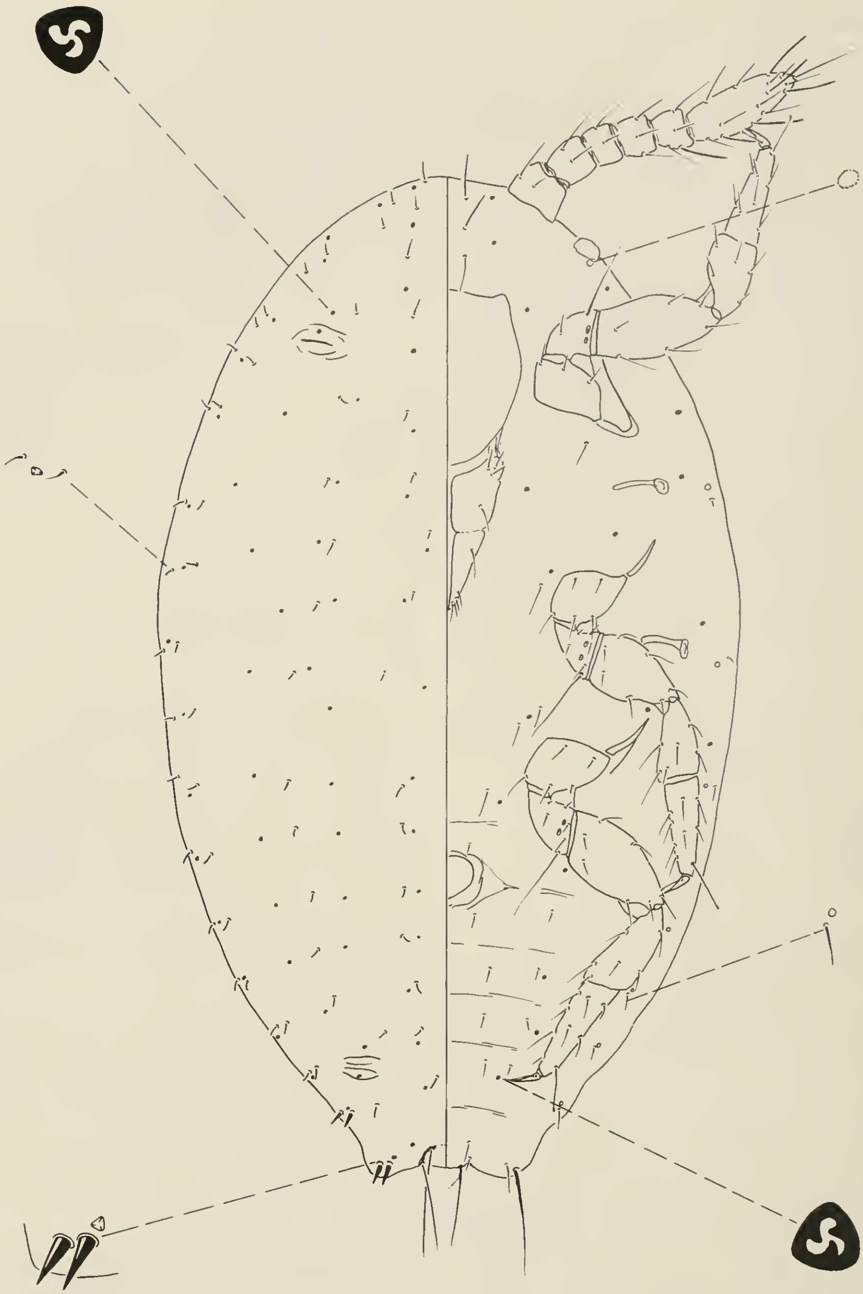

Fig. 4. First-instar (sex undetermined) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller.

cerarius 14 with 2(1–2) setae, cerarius 15 with 2(1–3) setae, cerarius 16 with 2(2–3) setae, cerarius 17 with 3(2–3) setae. Cerarius 12 with 2(1–3) trilocular pores, and 0(0–1) discoidal pores. Multilocular pores absent; trilocular pores scattered over surface; discoidal pores about equal to diameter of trilocular pores. Oral-collar tubular ducts of 1 size, same as large size on venter, present in rows across segments beginning on segment V or VI forward to head. Longest submedial seta on segment VII 16(12–19) μ long; 1(1–2) submedial setae on segment VIII, longest seta 14(10–20) μ long.

Anal ring seta 69(57–77) μ long; 1.5(1.3–1.7) times as long as greatest diameter of ring.

Venter without multilocular pores. Trilocular pores scattered over surface. Discoidal pores of same size as on dorsum, with 1(0–1) pores near each eye. With 2 sizes of oral-collar tubular ducts, larger size present in margin or submargin from segments VII or VI forward to head; smaller size in rows on segments VII and VI and occasionally on segment V, also present in medial and submedial areas of anterior abdominal segments, thorax, and head. Setae as follows: 4 cisanal setae, longest 23(19–32) μ long; longest anal-lobe seta 92(86–106) μ long; longest seta on trochanter 53(42–59) μ long.

Circulus 38(35–42) μ wide, divided by intersegmental fold. Labium 95(91–99) μ long. Antennae 6-segmented, 177(153–191) μ long. Legs without translucent pores. Femur 87(79–94) μ long; tibia 66(56–69) μ long; tarsus 67(63–69) μ long. Tibia/tarsus 1.0(0.9–1.0); femur/tibia 1.3(1.3–1.4). Hind tibia with 9 setae. Length of hind femur divided by greatest width of femur 2.3(2.1–2.4). Claw digitules same as on adult female. Tarsal digitules on hind 2 pairs of legs with 1 digitule with club and other apically acute and slightly shorter; tarsal digitules on front pair of legs of about same dimensions as other legs except apically acute digitule is very short.

Notes.—This description is based on 109 specimens from 3 localities. The second-instar male can be distiguished from all other instars by having dorsal oral-collar tubular ducts, mouthparts, and no vulva.

Third-instar Male (Prepupa)
(Fig. 6)

Slide-mounted characters.—Body elongate, 0.9 mm long, 0.4 mm wide.

Dorsum without cerarii, posterolateral margins of segments VI, VII, and VIII each with 2 setae conspicuously longer than remaining setae on segments. Multilocular pores scattered over surface except on mesothorax and abdominal segments VIII and IX; trilocular pores absent; discoidal pores associated with multilocular pores and oral collars. Oral-collar tubular ducts of 1 size, scattered over surface except on mesothorax and abdominal segments VIII and IX. Longest submedial seta on segment VII 17 μ long; 3 submedial setae on segment VIII, longest seta 15 μ long.

Anal ring without setae and pores.

Venter with multilocular pores scattered over surface except segments VIII and IX. Trilocular pores absent. Discoidal pores associated with multiloculars and oral collars. With oral-collar tubular ducts in marginal areas except on abdominal segments VIII and IX.

Circulus 82μ wide, divided by intersegmental fold. Mouth structure weakly indicated.Antennal segments indistinct, 232μ long. Legs without translucent pores. Femur 91μ long; division between tibia and tarsus indistinct, tibia+tarsus 148μ long. Wing buds of mesothoracic wings protruding from lateral margin, about 110μ long. Wing buds of hamulohalterae absent.

Notes.—The above description is based on 1 specimen reared in the Laboratory that originally was collected in Hammonton, New Jersey on *Vaccinium corymbosum*, March 19, 1996. Preserved June 6, 1996. A second specimen, field collected from the same locality and host on September 28, 1996, lacks all signs of wing buds and has a very weak indication of the circulus. We suspect that this specimen is a prepupa of the apterous male. The prepupa can be distiguished from all other instars by having, multilocular pores, oral-collar tubular ducts, antennae without definite segmentation, tibia and tarsus fused, no mouthparts, no aedeagus, no definite constriction for the head. It is most similar to the pupa which differs by having antennae 10-segmented and a definite constriction for head.

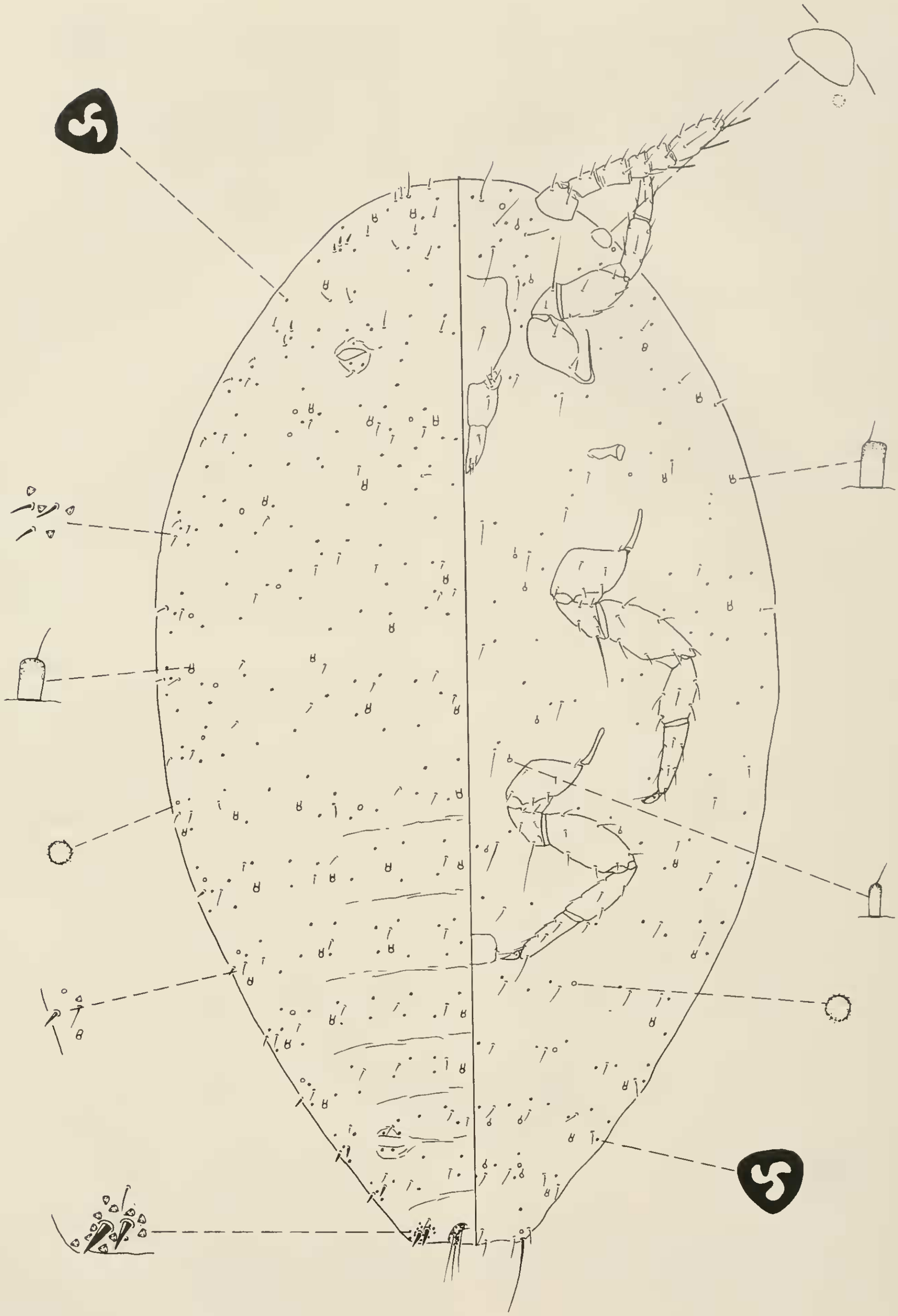

Fig. 5. Second-instar male *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, XI-1-1995, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller.

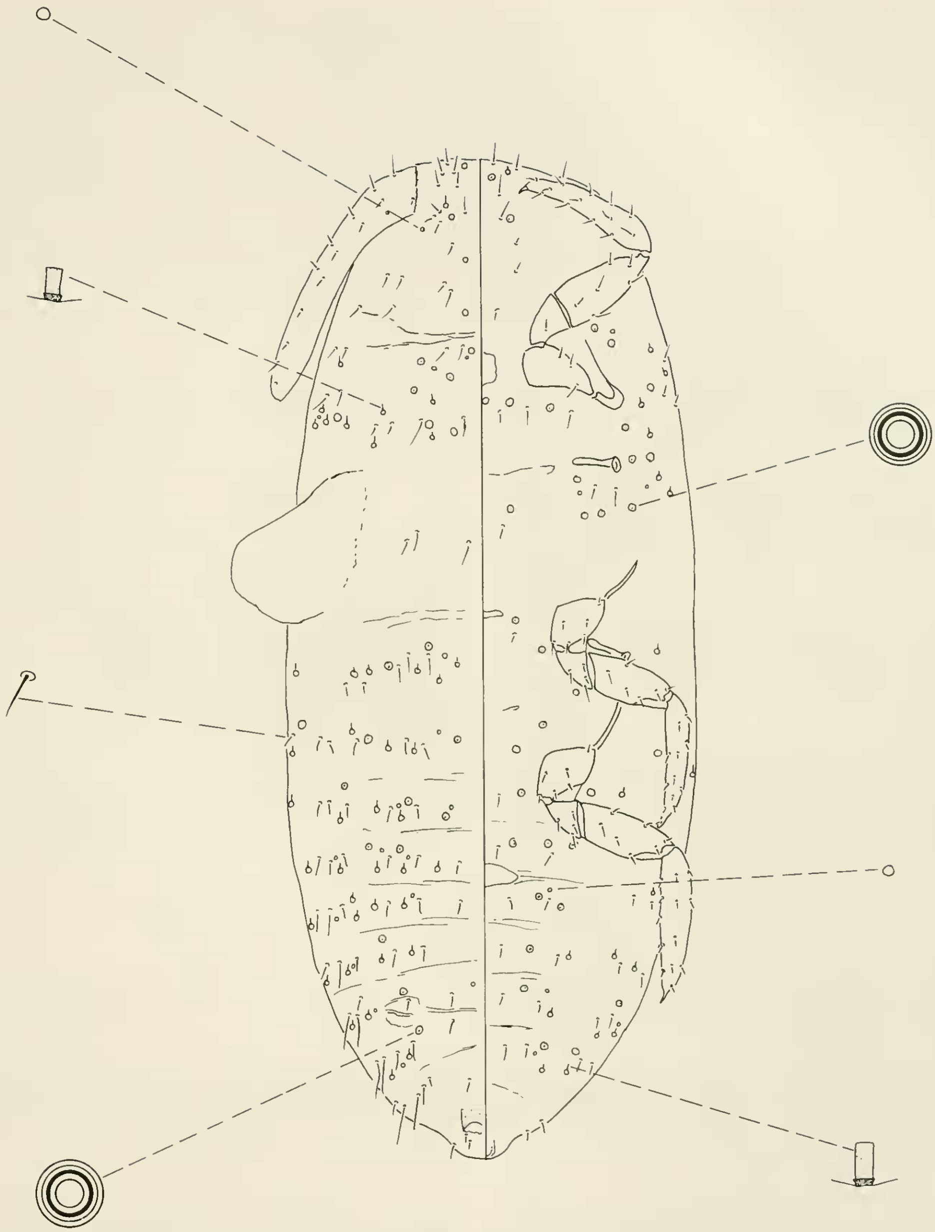

Fig. 6. Third-instar male (prepupa) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

FOURTH-INSTAR MALE (PUPA)
(Fig. 7)

Slide-mounted characters.—Body elongate, 1.0(0.9–1.1)mm long, 0.4(0.3–0.4)mm wide.Dorsum without cerarii, setae on posterolateral margins of segments VI, VII, and VIII each with 2 setae conspicuously longer than remaining setae on segements. Multilocular pores present in mediolateral areas of head, thorax, and abdo-

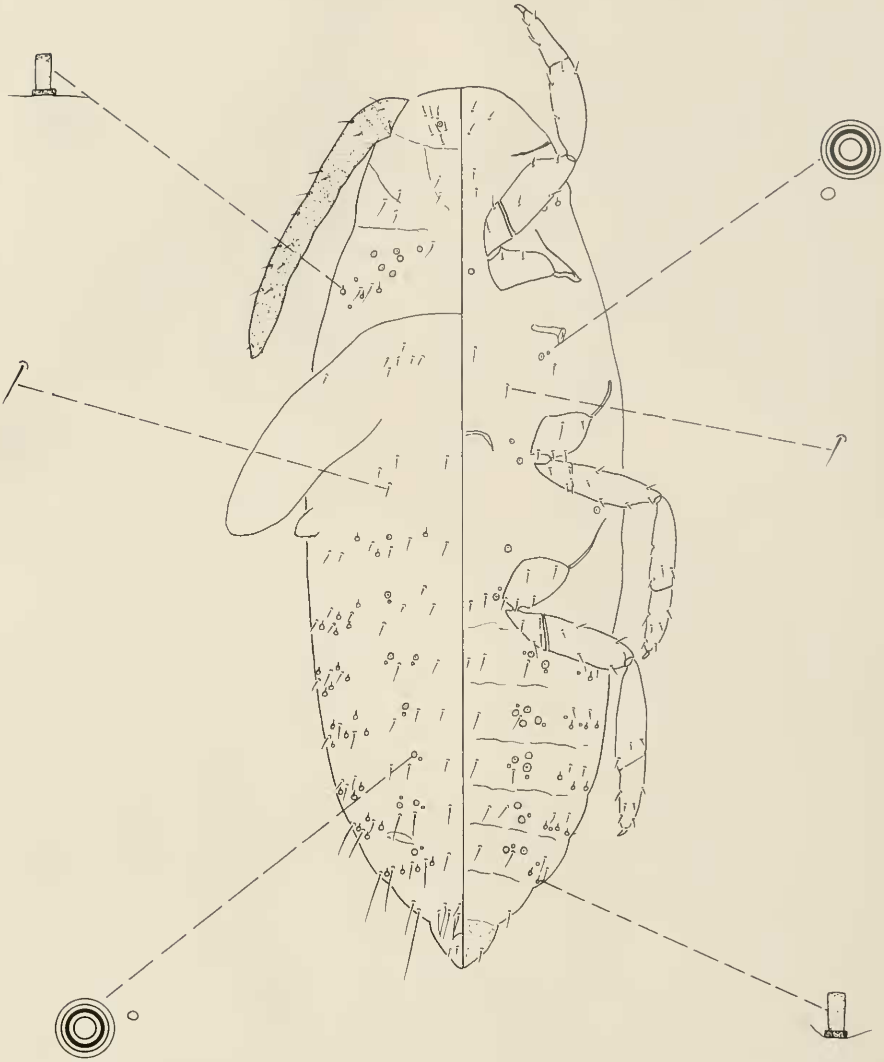

Fig. 7. Fourth-instar male (pupa) *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

men, most abundant on prothorax; trilocular pores absent; discoidal pores associated with multilocular pores. Oral-collar tubular ducts of 1 size, present in submarginal areas of prothorax and abdomen. Longest submedial seta on segment VII 29(25–30) μ long; 5(4–5) submedial setae on segment VIII, longest seta 30(25–32) μ long.

Anal ring without setae and pores.

Venter with multilocular pores in mediolateral areas of thorax and abdomen. Trilocular pores absent. Discoidal pores associated with multiloculars. With oral-collar tubular ducts in marginal areas of prothorax and abdominal segments II or III to VII. Postocular ridge and mesosternal furca evident.

Antennae 10-segmented, 368(353–384) μ long. Legs without translucent pores. Femur 117(111–121) μ long; tibia 122(116–128) μ long; tarsus 96(94–99) μ long. Tibia/tarsus 1.3(1.2–1.3); femur/tibia 0.9(0.9–

1.0). Wing buds of mesothorax protruding from lateral margin, 289(248–347) μ long. Wing buds of hamulohalterae represented by small protrusions on lateral margin of metathorax.

Notes.—The above description is based on 3 specimens reared in the laboratory that originally were collected in Hammonton, New Jersey, March 19, 1996 and preserved June 6, 1996. We suspect that these specimens are pupae of the macropterous form. Specimens have also been collected near Frankfort, Sussex Co., Delaware, April 5, 1996 (1); Hammonton, New Jersey, August 8, 1996 (1), September 28, 1996 (4), October 30, 1996 (1). In most of these specimens, the apterous adult is inside. The pupa does not have wing buds except for a slightly wrinkled area where the mesothoracic wing bud would be on the macropterous form. The pupa can be distinguished from all other instars by having multilocular pores, oral-collar tubular ducts, 10-segmented antennae, no mouthparts, no aedeagus, definite constriction for the head. It is most similar to the prepupa. For a comparison see the notes section of the prepupa.

Macropterous Adult Male
(Fig. 8)

Slide-mounted characters.—Body elongate oval, 1.0 mm long, 0.3 mm wide.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate setae about 355μ long, 1 or 2 additional shorter setae, 32(30–34) multilocular pores, and 2 or 3 discoidal pores. Multilocular pores in marginal areas of thorax and abdomen, with 4 or 5 loculi, quadriloculars most abundant. Discoidal pores associated with multiloculars, with 1 or 2 near base of antenna, occasionally with 1 or 2 such pores in medial areas of abdomen. Body setae of 2 kinds, fleshy setae and bristle shaped; both kinds scattered over surface. Abdominal sclerotization restricted to abdominal tergite VIII. Metapostnotal ridge conspicuous. Scutellum rectangular, without scutellar ridge, with several setae laterally. Scutum sclerotized throughout except with a median longitudinal clear area, area lateral of prescutum heavily sclerotized, with reticulate pattern, scutum with many setae. Prescutum rectangular, with weakly defined prescutal suture, with several setae along lateral and posterior margins. Pronotal ridges heavily sclerotized. Hamulohalterae 65(64–67) μ long, with 1 apical hooked seta. Mesothoracic wings 796(790–883) μ long, each with 2 or 3 basal setae and 2 discoidal pores. Dorsal arm of midcranial ridge extending to posterior margin of dorsal eye. Dorsal medialsclerite sclerotized with numerous setae. Dorsal eye about 32μ in diameter. Lateral ocellus 21(20–22) μ in diameter, located at junction of preocular and postocular ridges. Ocular sclerite lightly sclerotized.

Penial sheath 147(146–148) μ long, 78(77–79) μ wide; length/width ratio 1.9. Aedeagus 116(111–121) μ long, apically truncate.

Venter with setae of same 2 shapes as on dorsum, present medially, submedially and laterally on most segments, abundant on basisternum. Abdominal sclerotization confined to sternite VIII. Prosternal ridge well developed, sternite weakly sclerotized. Preoral ridge weakly developed. Ocular sternite sclerotized near ventral eye. Ventral midcranial ridge well developed, with lateral arms. Ventral eye about 37μ in diameter.

Hind femur 171(168–174) μ long; tibia 211(210–212) μ long; hind tarsus 90(86–94) μ long; femur/tibia 0.8; tibia/tarsus 2.4(2.3–2.4). Slender fleshy setae present on legs and antennae; apical segment of antenna with capitate setae. Tarsal digitules capitate; claw digitules acute. Antennae 10-segmented, 536(521–546) μ long; segment 3 longest, 73(72–74) μ long; segment 10, 70(69–72) μ long; segment 3/10 1.0(1.0–1.1).

Notes.—The above description is based on 2 specimens reared in the Laboratory that originally were collected in Hammonton, New Jersey on *Vaccinium corymbos-*

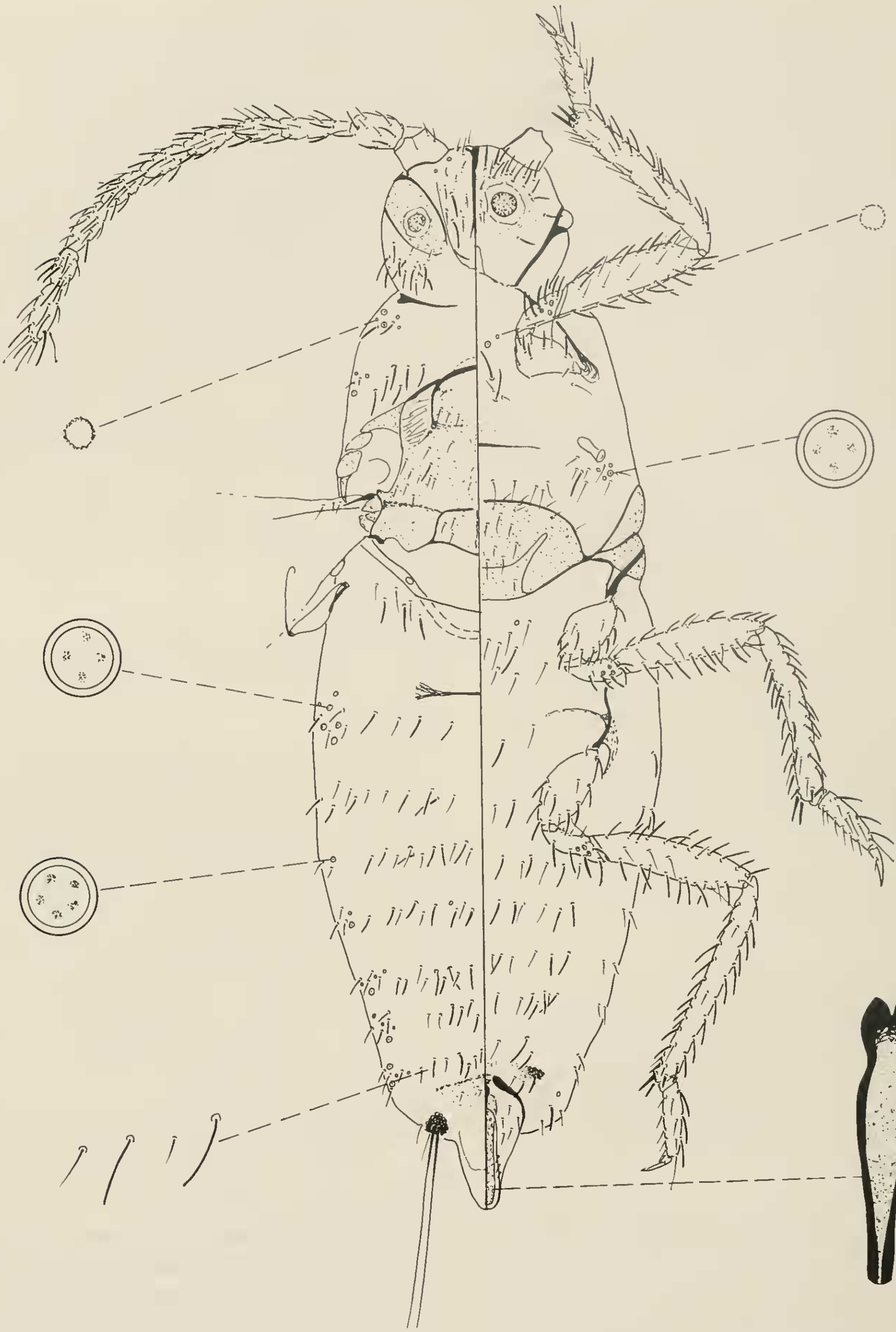

Fig. 8. Fifth-instar male (adult, macropterous form) *Dysmicoccus vaccinii*. Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum*, S. Polavarapu and D. R. Miller. Reared in laboratory VI-6-1996.

um, March 19, 1996 and preserved June 6, 1996. Another specimen with brachypterous wings was reared at the same time. It is virtually identical with the macropterous forms but has small round wing buds and no hamulohalterae. It is unclear if this is a specimen that was in the process of wing elongation or is a naturally occurring brachypterous form. This macropterous form of the adult male can be distinguished from all other instars by possessing wings, a definite aedeagus, lateral pore clusters, and a heavily sclerotized thorax and head.

Apterous Adult Male
(Fig. 9)

Slide-mounted characters.—Body elongate oval, 1.2(1.0–1.2) mm long, 0.4 mm wide.

Dorsum with 1 pair of tail-forming pore clusters; each cluster with 2 elongate setae 276(260–291) μ long, 1 or 2 additional shorter setae, 31(25–37) multilocular pores, and 2 or 3 discoidal pores. Multilocular pores in marginal areas of head, thorax and abdomen, with 3, 4, or 5 loculi, quadriloculars most abundant. Discoidal pores associated with multiloculars, with several near base of antenna, occasionally with 1 or 2 such pores in medial areas of abdomen. Body setae of 2 kinds, fleshy setae and bristle shaped; fleshy setae on abdomen, bristle-shaped setae scattered over surface. Abdominal sclerotization most conspicuous on abdominal tergite VIII and in lateral areas, weakly evident in mendial and submedial areas. Metapostnotal ridge inconspicuous. Scutellum, scutum, and prescutum fused into 1 sclerotized area. Hamulohalterae and mesothoracic wings absent. Dorsal arm of midcranial ridge variable, extending to posterior margin of dorsal eye in some specimens, represented by weak sclerotiztion on others. Dorsal medialsclerite unsclerotized with numerous setae, discoidals, and a few multilocular pores. Dorsal eye about 25(22–27) μ in diameter. Lateral ocellus 24(22–27) μ in diameter, located at junction of preocular and postocular ridges. Ocular sclerite lightly sclerotized.

Penial sheath 156(148–161) μ long, 87(79–91) μ wide; length/width ratio 1.8(1.7–2.0). Aedeagus 121(111–131) μ long, apically truncate.

Venter with setae of same 2 shapes as on dorsum, present medially, submedially and laterally on most segments, abundant on basisternum. Abdominal sclerotization confined to sternite VIII. Basisternum with anterior marginal ridge incomplete. Prosternal ridge well developed, sternite weakly sclerotized. Preoral ridge weakly developed. Ocular sternite sclerotized near ventral eye. Ventral midcranial ridge well developed, with lateral arms. Ventral eye about 33(30–35) μ in diameter.

Hind femur 181(172–191) μ long; tibia 210(200–221) μ long; hind tarsus 94(91–99) μ long; femur/tibia 0.8(0.8–0.9); tibia/tarsus 2.2(2.1–2.3). Slender fleshy setae present on legs and antennae; apical segment of antenna with capitate setae. Tarsal digitules capitate; claw digitules acute. Antennae 9- or 10-segmented, when 9-segmented, segments 4 and 5 fused, 486(477–502) μ long; segment 3 longest, 65(62–70) μ long; segment 10(9), 62(59–65) μ long; segment 3/10(9) 1.1(1.0–1.1).

Notes.—The above description is based on 5 specimens reared in the Laboratory that originally were collected in Hammonton, New Jersey on *Vaccinium corymbosum,* March 19, 1996 and preserved June 6, 1996. This form of the adult male can be distinguished from all other instars by having a definite aedeagus, lateral pore clusters, and a heavily sclerotized thorax and head, and by lacking wings.

Specimens Examined

Paratypes—DELAWARE: Near Frankford, Sussex County, IV-5-1996, on *Vaccinium* spp., S. Polavarapu and D. R. Miller (87 ad ♀, 48 third-instar ♀, 5 second-instar ♀, 1 fourth-instar pupal ♂, 28 second-instar ♂, 5 first instars) USNM. NEW JERSEY: Near Hammonton, Variety Farms, Atlantic

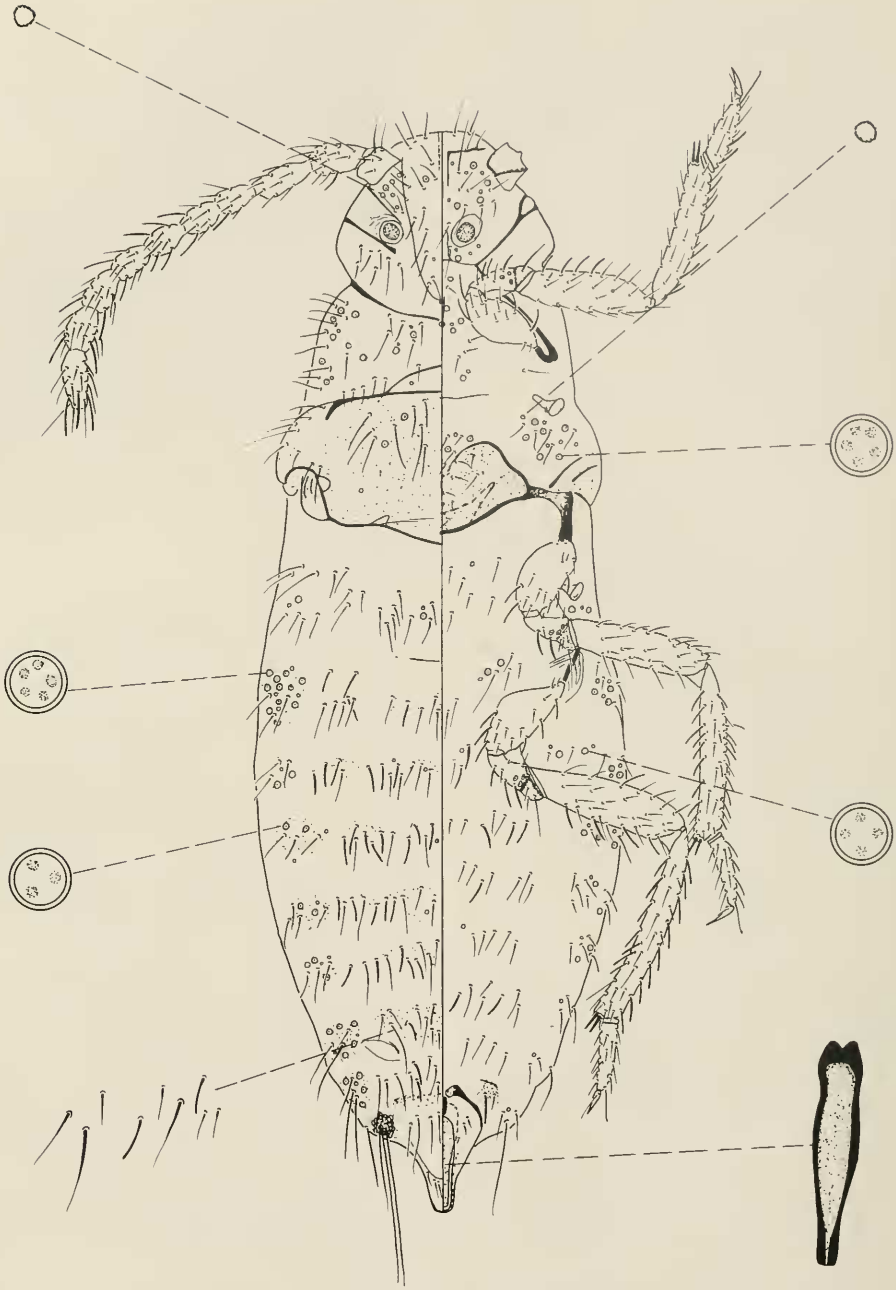

Fig. 9. Fifth-instar male (adult, apterous form) *Dysmicoccus vaccinii.* Hammonton, Variety Farms, Atlantic County, New Jersey, III-19-1996, on *Vaccinium corymbosum,* S. Polavarapu and D. R. Miller. Preserved after rearing in laboratory VI-6-1996.

County, V-12-1994, VI-7-1994, XI-17-1994, XII-30-1994, I-13-1995, III-14-1995, IV-14-1995, XI-1-1995, I-13-1995, II-12-1996, III-5-1996, III-19-1996, III-20-1996, IV-5-1996, IV-23-1996, V-6-1996, *Vaccinium* spp., (XI-1-1995 infestation also found on *Polygonum* sp.) D. R. Miller and/or S. Polavarapu (560 ad ♀, 235 third-instar ♀, 73 second-instar ♀, 2 macropterous ad ♂, 1 brachypterous ad ♂, 5 apterous ad ♂, 3 fourth-instar pupal ♂, 1 third-instar prepupal ♂, 75 second-instar ♂, 64 first instars) BMNH, CDA, FSCA, MHNH, UCD, USNM; Near Hammonton, MacCrie Brothers Farm, Atlantic County, III-5-1996, *Vaccinium* spp., S. Polavarapu and D. R. Miller (100 ad ♀, 30 third-instar ♀, 6 second-instar ♂, 1 first instar) USNM; Near Hammonton, MacCrie Brothers Farm, Atlantic County, VII-22-1993, IX-7-1993, IX-29-1993, *Vaccinium* spp., K. S. Samoil (24 ad ♀) USNM.

Not paratypes.—NORTH CAROLINA: Bailey, Nash County, I-25-1973, on *Vaccinium ashei,* H. H. Neunzig (6 ad ♂) USNM.

There is an additional series of specimens from the Hammonton locality that were collected August 8, 1996, September 28, 1996, and October 30, 1996. This material was mounted quickly for assessing the presence of different stages of the mealybug and therefore is not included in the type series. It includes 396 adult females, 139 third-instar females, 31 second-instar females, 111 first instars, 1 apterous adult male, 7 pupal fouth-instar males, 1 prepupal third-instar male, and 35 second-instar males. All of this material is deposited in the USNM.

Specimens collected in North Carolina are believed to be conspecific with *Dysmicoccus vaccinii* but have shorter appendages and shorter dorsal setae and therefore are not included in the type series. The submittal slip from H. H. Neunzig, North Carolina State reads "I am sending specimens collected from rabbit-eye blueberries (*Vaccinium ashei*) at a nursery in Bailey, N. C. They occur in large numbers and are forming galls on the roots. A white secretion is also associated with these insects." In New Jersey infestations we have never seen any indication of galls and have been unable to confirm their existence in North Carolina.

An additional series of specimens including 9 adult females, 3 third-instar females, and 4 first instars, was submitted to the Systematic Entomology Laboratory in 1984 by Donald Ramsdell of Michigan State University. Data on the slides indicate only that the specimens were collected on blueberry in New Jersey in November 1984. Since we do not have specific locality information, this series has not been included in the type series. The specimens fall well within the range of variation of *Dysmicoccus vaccinii.*

Field results.—Sampling of field populations during late fall of 1995 through fall of 1996 revealed the presence of various immature and adult stages throughout the sampling period (Fig. 10). Although second-instar males were consistently present, the adult males were found in the field only four times. One pupa was collected near Frankford, DE on April 5, 1996. In Hammonton, NJ male stages after the second instar were collected in the field on the following dates: one pupa (August 8, 1996); one prepupa, 4 pupae, and one apterous adult male (September 28, 1996); 2 pupae (October 30, 1996).

Adult females collected from the field during January and February readily oviposit in the laboratory. Eggs are laid within an ovisac made of wax filaments. *Dysmicoccus vaccinii* apparently has more than one generation each year in New Jersey.

In our field observations, we have always found *D. vaccinii* populations associated with the ants, *Acanthomyops claviger* (Roger) or *Lasius neoniger* Emery. These ant species were seen tending all stages of mealybugs. Ants were also seen carrying mealybugs especially in response to disturbance.

Discussion and Conclusions

Dysmicoccus vaccinii is part of a complex of mealybugs characterized by Beardsley (1965) as the *D. brevipes* group or the pineapple mealybug complex. Morphologically, they are recognized as species of *Dysmicoccus* that have most of the following characters: discoidal pores near the rim of the eye, multilocular pores restricted to the ventral surface of the abdomen, a cir-

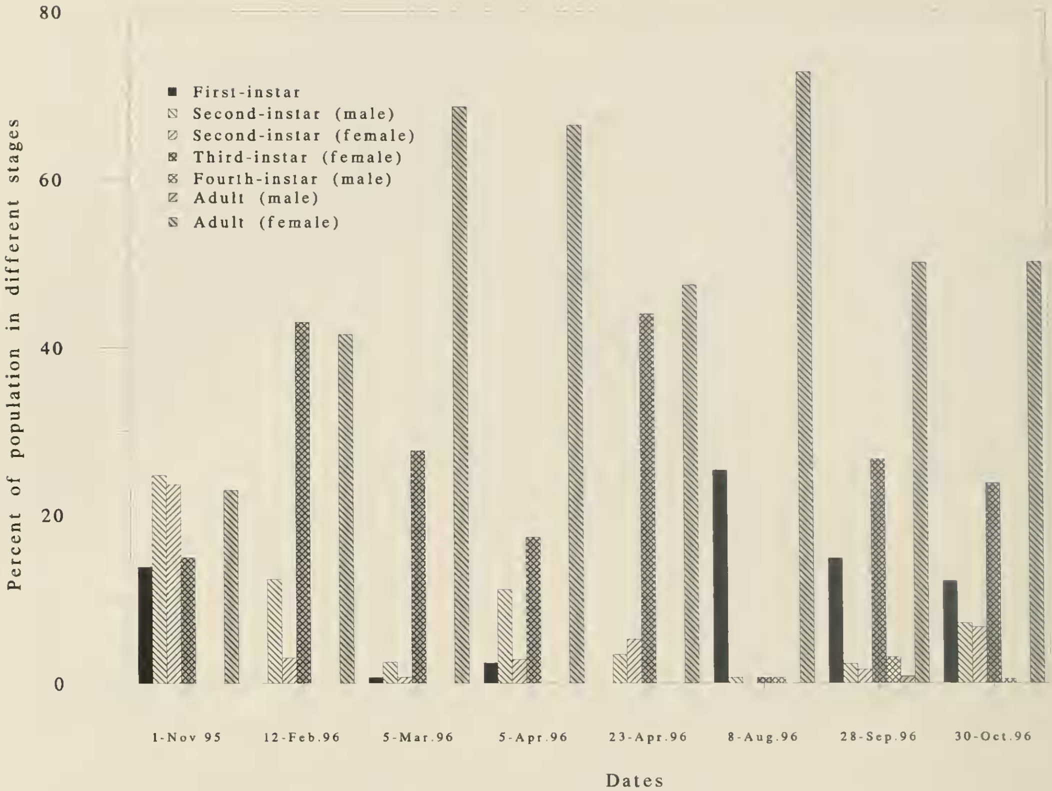

Fig. 10. Distribution of immature and adult stages of *D. vaccinii* on blueberries during November, 1995 to October, 1996, near Hammonton, New Jersey. Third-instar males are not included but one specimen was collected 9/28/96 and is 0.8% of total for that collection. Sample size was 65–439 mealybugs on different sampling dates.

culus divided by the intersegmental line, 17 pairs of cerarii, and translucent pores on at least the hind femur and tibia. With the addition of *Dysmicoccus vaccinii* to the group there now are 12 species in the complex including *D. brevipes, D. grassii* (Leonardi), *D. mackenziei* Beardsley, *D. morrisoni* (Hollinger), *D. neobrevipes* Beardsley, *D. pinicolus* McKenzie, *D. probrevipes* (Morrison), *D. radicis* (Green), *D. roseotinctus* (Cockerell and Cockerell), *D. texensis,* and *D. tibouchinae* (Hambleton).

The adult female of *Dysmicoccus vaccinii* is very similar to *D. texensis,* but differs by having no oral collars on the head, 1 size of oral collar on the body, the length of the hind femur divided by greatest width of the femur 3.1(2.9–3.4), and the longest dorsomedial seta on segment VIII 34(25–42) μ long. *Dysmicoccus texensis,* has several oral collars near the anterior margin of the head, 2 distinct sizes of oral collars, the length of hind femur divided by the greatest width of femur 2.0(1.9–2.1), and the longest dorsomedial seta on segment VIII 21(20–23) μ long.

The adult macropterous male is similar in appearance to the adult male of *Dysmicoccus grassii* (=*Dysimcoccus alazon* Williams) as described by Afifi (1968) but has an apically blunt aedeagus whereas *D. grassii* has an apically acute aedeagus. It also is similar to *Dysmicoccus brevipes* (Cockerell) and *D. neobrevipes* Beardsley as described by Beardsley (1965). *Dysmicoccus brevipes* and *D. neobrevipes* differ by having the apex of the aedeagus bifurcate; *D. neobrevipes* also has numerous short, enlarged setae on the antennae which do not occur in *D. vaccinii, D. grassii,* or *D. brevipes.*

The key to adult females of North American species of mealybugs presented by Miller and McKenzie (1973) needs to be modified as follows to accommodate *Dysmicoccus vaccinii.*

27(26). Oral-collar tubular ducts with dermal orifices noticeably larger in diameter than trilocular pores; lateral abdominal clusters of oral-collar tubular ducts each with fewer than 10 ducts . . . . *aurantius* (Cockerell)
– Oral-collar tubular ducts with dermal orifices smaller than or equal to diameter of trilocular pores; lateral abdominal clusters of oral-collar tubular ducts each with more than 10 ducts 28
28(27). Without oral-collar tubular ducts on head; with only 1 size of oral collar . . . . *vaccinii* Miller and Polavarapu
– With oral-collar tubular ducts on head; with 2 sizes of oral collars . . . . *texensis* (Tinsley)

One morphological result merits further discussion. As has been suggested previously (Miller 1975) the value derived from dividing the hind tibia length by the hind tarsus length is distinctive for each immature instar. In *D. vaccinii* these values are: adult female 2.0(1.8–2.3); third-instar female 1.2(1.1–1.2); second-instar female 0.9; second-instar male 1.0(0.9–1.0); first-instar 0.8(0.7–0.8). The interesting observation is that the value derived from dividing the hind femur length by the hind tibia length is basically the same for all instars. In *D. vaccinii* these values are: adult female 1.1(1.1–1.2); third-instar female 1.3(1.2–1.4); second-instar female 1.4(1.3–1.4); second-instar male 1.3(1.3–1.4); first-instar 1.4(1.3–1.5); only the adult female differs from the rest. Therefore, it appears that the tarsus is growing at a different rate than the other measurable segments of the leg.

In many insects, the diapausing stage is species-specific, and is reached prior to the arrival of adverse environmental conditions (Tauber et al. 1986). The occurrence of immature and adult stages of *D. vaccinii* throughout the fall and winter suggests the possibility that this insect does not have a true overwintering stage, although this does not preclude the possibility of overlapping diapausing and non-diapausing generations. For instance, the early-instar nymphs and mature adult females found during late fall and winter may represent diapausing and non-diapausing generations, respectively. Mature females collected during winter readily resume oviposition in the laboratory at 20–23°C. This suggests that mature mealybugs are in a state of quiescence awaiting the onset of favorable temperatures.

In the present study, the majority of the sampled population consisted of adult females at most times of the year. This may be partially attributed to the sampling bias against the immature stages of the mealybug population. Nevertheless, field samples collected throughout the study always consisted of immature stages including second-instar males. There may be a trend towards an increasing percentage of third-instar and adult females as winter progresses, but a more rigorous sampling regime is required to confirm this observation. Our failure to collect adult males on a regular basis, in spite of the common occurrence of second-instar males in the field, is difficult to explain. It is entirely possible that we simply are not locating the adults because of their small size and short life span. Clearly, more work is needed to understand the biology and seasonal life-history of *D. vaccinii.*

Ant-mealybug mutualistic relationships have been previously documented in the genus *Dysmicoccus* (e.g., Carter 1932; Milliron 1958; Beardsley et al. 1982; Rohrbach et al. 1988). Several species of ants feed on honeydew produced by the gray pineapple mealybug, *Dysmicoccus neobrevipes.* The ants are reported to benefit this mealybug species by providing protection from natural enemies and adverse weather conditions, by transporting the mealybugs among plants, and by removing honeydew which prevents sooty mold buildup (Rohrbach et al. 1988). Recent studies under laboratory conditions, however, failed to demonstrate the role of the big-headed ant, *Pheidole megacephala* (F.) in increasing the mealybug colony size or in transporting the mealybugs (Jahn and Beardsley 1996). Future research should evaluate the role of ants in maintaining populations of *D. vaccinii* in blueberry fields, to determine whether mealybug control strategies involving the management of ant populations should be developed and implemented.

Acknowledgments

Thanks to Ms. Elizabeth Bender, Blueberry and Cranberry Research Center, Rutgers University (BCRC) for assisting in collection of field samples. We also thank Dr. Robin Stuart, BCRC for collecting some of the male mealybug specimens and for his comments and observations on ant-mealybug interactions. We are grateful to David R. Smith, Systematic Entomology Laboratory, Agricultural Research Service, United States Department of Agriculture, Washington, D.C. (SEL), for identifying the ant species. To Mr. John Bertino of Variety Farms we gratefully acknowlege his willingness to let us sample mealybugs in his blueberry fields. This research was partially funded by USDA-ARS-CSREES (93-34155-8382) awarded to SP.

We are grateful to the following individuals for reading and commenting on the manuscript: Dr. John A. Davidson, Department of Entomology, University of Maryland, College Park; Dr. William F. Gimpel, Jr., Plant Protection Section, Maryland Department of Agriculture, Annapolis; Dr. Michael E. Schauff and Dr. E. Eric Grissell of SEL. We also wish to acknowledge the important contribution of Ms. Debra Creel of SEL who prepared more than a thousand specimens of this new species.

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